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RESEARCH ARTICLE

Effects of Intermittent Traction Therapy in an Experimental Spinal Column Model

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Abstract
Traction therapy, which is known to be a treatment method for scoliosis, one of many muscles disease, has been used since Hippocrates introduced it. However, the effects of traction therapy are still not clear. In addition, the meridian sinew theory, which is related to muscle treatment and is mentioned in the book on meridian sinews in the Miraculous Pivot of Huangdi's Internal Classic, has not been the subject of much study. For these reasons, experimental spinal models were made for this study to observe and analyze the lengths of vertebral interspaces after intermittent traction therapy, which is known to be excellent among muscle treatment methods, with various tensile forces. The results showed that the effects of intermittent traction therapy were unclear and that it might be harmful, especially when the pain was induced by muscle weakness. Because the results of this study on intermittent traction therapy were different from those expected from osteopathy or craniosacral theory, better studies of the subject are necessary.

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1. Introduction

The meridian sinew theory was introduced to address the locations of meridian sinews, as well as the causes, mechanisms, and treatments of the diseases discussed in the chapter on meridian sinew in Miraculous Pivot, Huangdi's Internal Classic [1]. A meridian sinew, which was mentioned in meridian sinew theory, was not understood as a certain single muscle, but as the following: a muscle and its functions, as well as the relationships between the functions of the muscles and the symptoms of diseases [1]; as a single muscle including the ligaments and tendons that are connected to the bone and control the movement of the muscle, so that movement of the muscle sinew controls the action of the muscle [1,2]; as simply a single muscle or many muscles [3]; and as the system and organization of body muscles consisting of muscles, ligaments, tendons, fascia, etc. [1—4]. This understanding of the meridian sinew recognizes the importance of muscle function or movement for treatment in traditional Oriental medicine. Some recognition of the importance of muscles for the treatment of diseases was present in ancient European medicine, and traction therapy, which is thought to have been introduced by Hippocrates [circa 460—350 before common era (BC)], has been used to treat scoliosis [5].

Traction therapy aims to remove pain and to reduce pressure in nerve roots by increasing negative pressure in the spinal column using mechanical forces in the body to stretch muscles and to reduce the pressure caused in the spinal column by gravity [6]. Factors that are known to influence the effects of traction therapy are the traction force, traction time, traction angle, treatment time, posture of the patient during treatment, etc. [7]. Intermittent traction therapy (ITT) is a method in which the traction force and time are changed to make the therapy more effective [8]. Intermittent traction helps to relieve pain by improving the circulation to the tissues and by reducing the swelling of tissues. Gentle alternation of stretching and relaxation of the spinal column's soft tissue structures prevents the formation of adhesions of the dural sleeve [9].

The effects of traction therapy in treating diseases are unclear in many studies [10], but Clarke et al [11] asserted that this was because in clinical cases, the effects of traction were difficult to determine scientifically due to: (1) difficulties in setting up a control group; (2) difficulties in conducting blind tests with a mechanical traction stress; (3) different education levels of the patients; (4) different understandings of the mechanisms of diseases; and (5) different causes possibly having the same symptoms, as well as different symptoms possibly having the same cause. Therefore, this study was designed to determine the effects of traction therapy, especially ITT because it is expected to be more effective in treating diseases, in an experimental spinal model. The traction lengths were compared and analyzed with different traction forces. The results should be used as fundamental data to improve the traction methods and to develop the method for meridian sinew treatment.

2. Materials and methods

Each of the vertebrae was made of lumber with dimensions of 68 mm × 88 mm × 38 mm. The rubber bands (Hyupsin Co. Ltd., Kwangju, Korea) were used after testing under a tensile force of 250 g when pulling a distance of 15 cm. Four of the vertebrae and the rubber bands were used to make an articulated spine model with three spinal joints. The spinal ligament of the model was made by using 120-cm horizontal and vertical beams to prevent deflections in unwanted directions. The anchoring site and the tensioning site of the model were designated, and the joints were named the first, second, and third joints, depending on their distance from the anchoring site, with the first joint being nearest the anchoring site (Fig. 1).

The normal articulated spine model has two types. The first is normal type 1 (NT 1), in which the three spinal joints are equally relaxed (VB1—VB2—VB3—VB4; VB1—4 indicate the first—fourth vertebral bodies, respectively; — indicates one rubber band). The other is normal type 2 (NT 2), in which the three spinal joints were equally tensioned (VB1=VB2=VB3=VB4; = indicates two rubber bands). Because the forces on the spine are different, depending on the patient, Model 1 is used for patients whose spines are relaxed and who have no pain, and Model 2 is used for patients whose spines are tensioned. Model 1 used one rubber band for a relaxed condition, and Model 2 used two rubber bands for a tensioned condition. Based on the hypothesis that muscle shortening of a certain joint region causes scoliosis with pain, we set the second spinal joint of the abnormal type (AT) 1 model under tension by using two rubber bands (VB1—VB2=VB3—VB4) and the second spinal joint of the AT 2 model under relaxation by using one rubber band (VB1=VB2—VB3=VB4).

New rubber bands, which had the same tensile force, replaced the old rubber bands after completion of the NT 1, NT 2, AT 1, and AT 2 experiments. The tractions were completed three times by stretching for 2 minutes each with forces of 400 g (600 g) and 200 g (400 g). Note that the forces are given in terms of the masses used to exert the forces; thus, the force in SI units of Newtons is the product of the mass in kg and the acceleration due to gravity in m/s^2. The distances between vertebrae were measured by using burner calipers (Fuji, Japan; Fig. 2).

2.1. Statistical treatment

All experiments were repeated three times, and the data are presented as designated by means ± standard deviations. Origin 6.0 software was used for the statistical

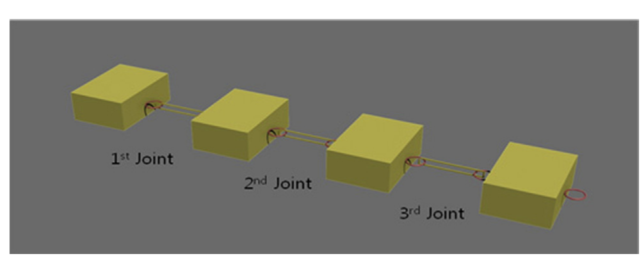

Figure 1 The multijoint model of the spinal column.

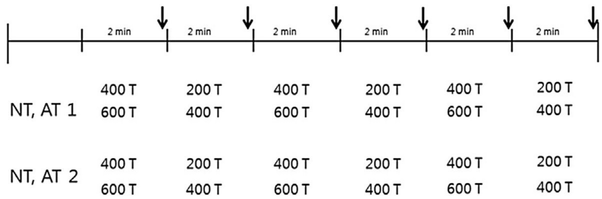

Figure 2 The intermittent traction method in the spinal column model. NT, AT 1 = normal and abnormal type 1; NT, AT 2 = normal and abnormal type 2. ↓ represents the measurement times for the traction lengths of the rubber bands.

analysis, and two variables for which statistical significance ($p < 0.05$) might be observed by using the ANOVA method were designated using the *t* test.

3. Results

The traction effects from the ITT stimulations under the NT 1 condition were observed for the intermittent actions of tensile forces of 400 g, 200 g (Fig. 3A, first time) and 600 g, 400 g (Fig. 3B, second time). When the tractions were conducted with a 400-g tensile force, the band lengths from the first to the third vertebral joints were 19.29 ± 0.38 cm, 20.87 ± 0.33 cm, and 24.25 ± 0.25 cm, respectively; the

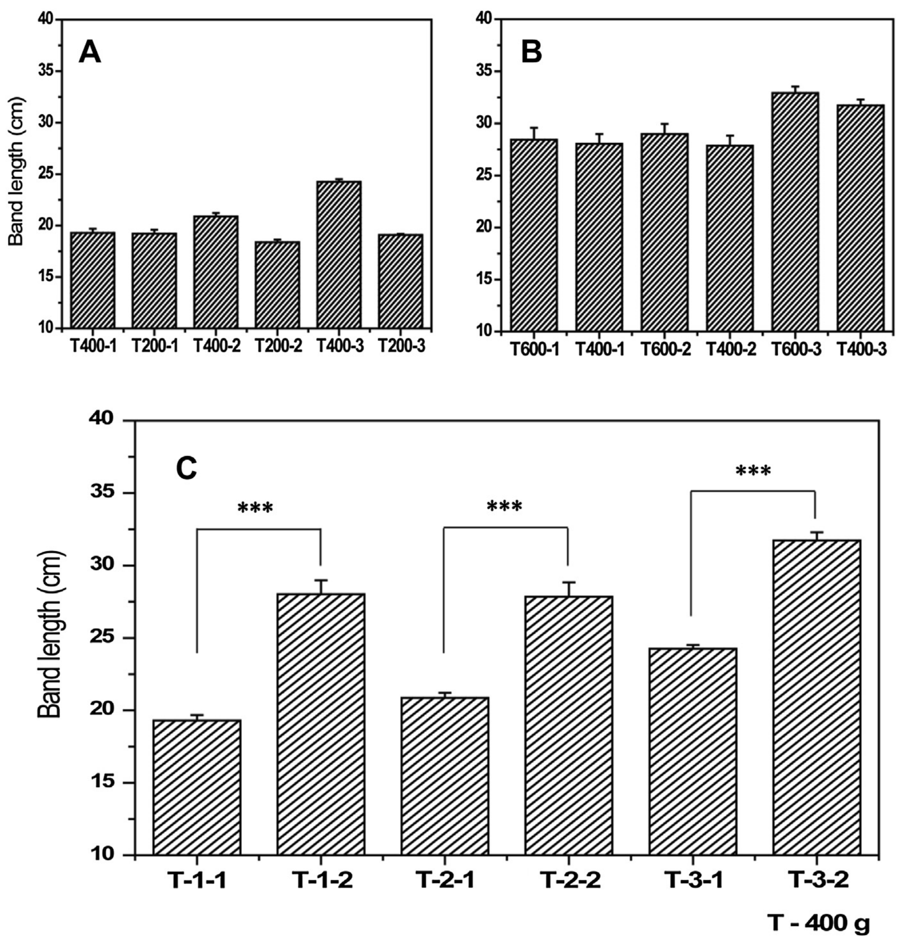

Figure 3 The effects of intermittent traction therapy in the articulated spine model under the NT 1 condition. Intermittent traction was completed three times for 2 minutes each time with tensile forces of (A) 400 g and 200 g and (B) 600 g and 400 g in series. The distance between vertebrae was measured using burner calipers. In (A), T400 and T200 are 400-g and 200-g tensile forces. T400-1, 2, 3 are the distances that the first, second, and third vertebrae were pulled apart by a 400-g tensile force. T200-1, 2, 3 are the distances that the first, second, and third vertebrae were pulled apart by a 200-g tensile force. In (B), T600 and T400 are 600-g and 400-g tensile forces. T600-1, 2, 3 are the distances that the first, second, and third vertebrae are pulled apart by a 600-g tensile force. T400-1, 2, 3 are the distances that the first, second, and third vertebrae were pulled apart by a 400-g tensile force. In (C), the graphs of the lengths that the bands were stretched by a 400-g tensile force are compared for the 400–200 g and 600–400 g intermittent traction methods. T-1-1, T-2-1, T-3-1 are the distances that the first, second, and third vertebrae were separated when using the 400–200 g intermittent traction method. T-1-2, T-2-2, T-3-2 are the distances that the first, second, and third vertebrae were separated when using the 600–400 g intermittent traction method. All data are expressed as means ± standard deviations, triplicate. *** $p < 0.001$. NT = normal type.

band lengths in the first, second, and third vertebral joints for a 200-g tensile force were 19.21 ± 0.38 cm, 18.37 ± 0.25 cm, and 19.09 ± 0.10 cm, respectively (Fig. 3A). The band lengths in the first, second, and third vertebral joints after traction were 28.43 ± 1.16 cm, 28.97 ± 0.99 cm, and 32.93 ± 0.61 cm, respectively, for a 600-g tensile force and 28.02 ± 0.96 cm, 27.83 ± 0.99 cm, and 31.73 ± 0.56 cm for a 400-g tensile force (Fig. 3B). When the tractions in the first and the second joints were compared for a 400-g tensile force, the band lengths were 19.29 ± 0.38 cm and 28.02 ± 0.96 cm in the first, 20.87 ± 0.33 cm and 27.83 ± 0.99 cm in the second, and 24.25 ± 0.25 cm and 31.73 ± 0.56 cm in the third vertebral joint (Fig. 3C).

The traction effects from ITT stimulations under AT 1 condition were compared for the intermittent actions of tensile forces of 400 g, 200 g (Fig. 4A, first time) and 600 g, 400 g (Fig. 4B, second time). The band lengths in the first, second, and third vertebral joints after traction were 19.23 ± 0.24 cm, 12.78 ± 0.03 cm, and 21.56 ± 0.21 cm, respectively, for a 400-g tensile force and 18.59 ± 0.67 cm, 11.95 ± 0.19 cm, and 15.56 ± 0.54 cm for a 200-g tensile force (Fig. 4A). For a 600-g tensile force, the band lengths in the first, second, and third vertebral joints after traction were 29.06 ± 1.03 cm, 16.20 ± 0.36 cm, and 30.28 ± 0.70 cm, respectively, and for a 400-g tensile force, they were 27.79 ± 0.31 cm, 13.71 ± 0.02 cm, and 27.54 ± 0.43 cm (Fig. 4B). When the tractions in the first and the second traction were compared for a 400-g tensile force, the band lengths were 19.23 ± 0.24 cm and 27.79 ± 0.70 cm in the first vertebral joint, 12.78 ± 0.03 cm and 13.71 ± 0.02 cm in the second, and 21.56 ± 0.21 cm and 27.54 ± 0.43 cm in the third (Fig. 4C).

The band lengths under the NT 1 and the AT 1 conditions were compared for tractions conducted at a 400-g tensile force (Fig. 5). When the traction was conducted with a 400-g tensile force after intermittent stimulation by 400-g and 200-g tensile forces, the band lengths in the first vertebral joint were 19.29 ± 0.39 cm under the NT condition and 19.22 ± 0.24 cm under the AT condition. When the traction was conducted with a 400-g tensile force after intermittent stimulation by 600-g and 400-g tensile forces, the band lengths in the first vertebral joint were 28.02 ± 0.96 cm under the NT condition and 27.79 ± 0.31 cm under the AT condition. When the traction was conducted with a 400-g tensile force after intermittent stimulation by 400-g and

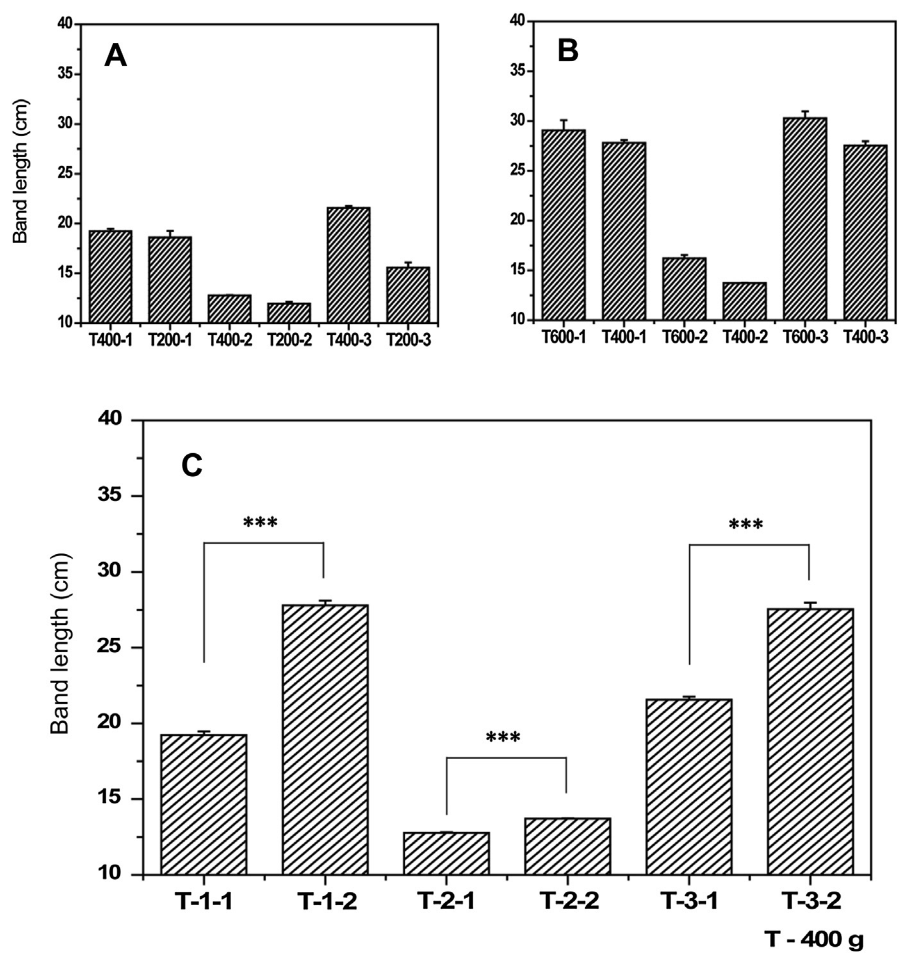

Figure 4 The effects of intermittent traction therapy in articulated spine model under the AT 1 condition (VB1—VB2 = VB3—VB4). The AT 1 model was based on the hypothesis that muscle contraction of a certain joint region causes spinal disease with pain, so the second joint of the articulated spinal model was placed under tension by using two rubber bands. The intermittent traction method was completed three times by stretching for 2 minutes each time with forces of 400 g (600 g) and 200 g (400 g). All data are expressed as means ± standard deviations, triplicate. *** $p < 0.001$. AT = abnormal type; VB = vertebral body.

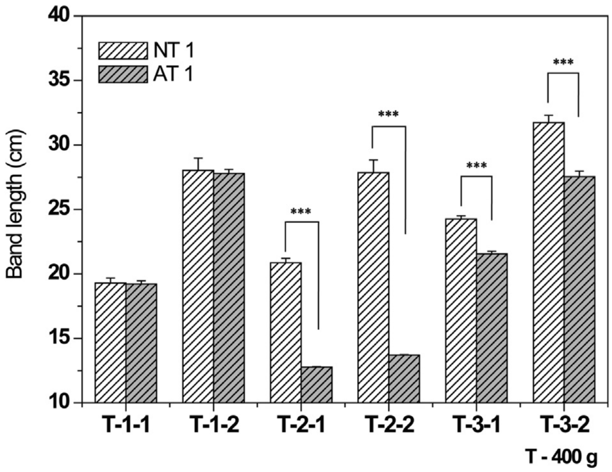

Figure 5 Comparison of the intermittent traction method under the NT 1 and the AT 1 conditions stretched by a 400-g tensile force. In the intermittent traction method used to compare the traction effects, the vertebrae were pulled apart by 400—200 g tensile force and 600—400 g tensile force for 2 minutes in the NT 1 model and the AT 1 model. T-1-1, T-2-1, T-3-1 are the distances a 400-g tensile force separated the first, second, and third vertebrae, which had been pulled apart by the 400—200 g intermittent traction method. T-1-2, T-2-2, T-3-2 are the distances a 400-g tensile force separated the first, second, and third vertebrae, which had been pulled apart by the 600—400 g intermittent traction method. All data are expressed as means ± standard deviations, triplicate. *** $p < 0.001$. AT = abnormal type; NT = normal type.

200-g tensile forces, the band lengths in the second vertebral joint were 20.87 ± 0.33 cm under the NT condition and 12.78 ± 0.33 cm under the AT condition. When the traction was conducted with a 400-g tensile force after intermittent stimulation by 600-g and 400-g tensile forces, the band lengths in the second vertebral joint were 27.84 ± 0.99 cm under the NT condition and 13.71 ± 0.02 cm under the AT condition. When the traction was conducted with a 400-g tensile force after intermittent stimulation by 400-g and 200-g tensile forces, the band lengths in the third vertebral joint were 24.25 ± 0.26 cm under the NT condition and 21.56 ± 0.21 cm under the AT condition. When the traction was conducted with a 400-g tensile force after intermittent stimulation by 600-g and 400-g tensile forces, the band lengths in the third vertebral joint were 31.73 ± 0.57 cm under the NT condition and 27.54 ± 0.43 cm under the AT condition.

The traction effects from ITM stimulations under the NT 1 condition were compared for the intermittent actions of tensile forces of 400 g, 200 g (Fig. 6A, first times) and 600 g, 400 g (Fig. 6B, second times). The band lengths in the first, second, and third vertebral joints after traction were 13.22 ± 0.15 cm, 13.67 ± 0.14 cm, and 14.57 ± 0.22 cm, respectively, for a 400-g tensile force and 13.01 ± 0.16 cm, 12.62 ± 0.10 cm, and 12.40 ± 0.10 cm for a 200-g tensile force (Fig. 6A). For a 600-g tensile force, the band lengths in the first, second, and third vertebral joints after traction were 16.58 ± 0.38 cm, 17.05 ± 0.25 cm, and 17.17 ± 0.05 cm, respectively, and for a 400-g tensile force, they were 16.18 ± 0.06 cm, 15.46 ± 0.12 cm, and 15.43 ± 0.24 cm (Fig. 6B). When the tractions in the first and second traction were compared for a 400-g tensile force, the band lengths were 13.22 ± 0.15 cm and 16.18 ± 0.06 cm in the first vertebral joint, 13.67 ± 0.14 cm and 15.46 ± 0.12 cm in the second, and 14.57 ± 0.22 cm and 15.43 ± 0.24 cm in the third (Fig. 6C).

The traction effects from ITM stimulations under the A2 condition were compared for the intermittent actions of tensile forces of 400 g, 200 g (Fig. 7A, first time) and 600 g, 400 g (Fig. 7B, second time). The band lengths in the first, second, and third vertebral joints after traction were 12.29 ± 0.10 cm, 18.54 ± 0.38 cm, and 13.50 ± 0.07 cm, respectively, for a 400-g tensile force and 11.91 ± 0.09 cm, 15.18 ± 0.28 cm, and 11.74 ± 0.20 cm for a 200-g tensile force (Fig. 7A). For a 600-g tensile force, the band lengths in the first, second, and third vertebral joints after traction were 15.19 ± 0.46 cm, 27.76 ± 0.88 cm, and 15.35 ± 0.31 cm, respectively, and for a 400-g tensile force, they were 14.62 ± 0.70 cm, 26.31 ± 1.42 cm, and 13.62 ± 0.50 cm (Fig. 7B). When the tractions in the first and second traction were compared for a 400-g tensile force, the band lengths were 12.29 ± 0.10 cm and 14.62 ± 0.70 cm in the first vertebral joint, 18.54 ± 0.38 cm and 26.31 ± 1.42 cm in the second, and 13.50 ± 0.07 cm and 13.62 ± 0.50 cm in the third (Fig. 7C).

When the tractions were conducted with a 400-g tensile force, the band lengths under the NT 2 and the AT 2 conditions were compared as shown in Fig. 8. When the traction was conducted with a 400-g tensile force after intermittent stimulation by 400-g and 200-g tensile forces, the band lengths in the first vertebral joint were 13.22 ± 0.15 cm under the NT condition and 12.29 ± 0.10 cm under the AT condition. When the traction was conducted with a 400-g tensile force after intermittent stimulation by 600-g and 400-g tensile forces, the band lengths in the first vertebral joint were 16.18 ± 0.06 cm under the NT condition and 14.62 ± 0.70 cm under the AT condition. When the traction was conducted with a 400-g tensile force after intermittent stimulation by 400-g and 200-g tensile forces, the band lengths in the second vertebral joint were 13.67 ± 0.14 cm under the NT condition and 18.54 ± 0.38 cm under the AT condition. When the traction was conducted with a 400-g tensile force after intermittent stimulation by 600-g and 400-g tensile forces, the band lengths in the second vertebral joint were 46 ± 0.12 cm under the NT condition and 26.31 ± 1.42 cm under the AT condition. When the traction was conducted with a 400-g tensile force after intermittent stimulation by 400-g and 200-g tensile forces, the band lengths in the third vertebral joint were 14.56 ± 0.22 cm under the NT condition and 13.50 ± 0.07 cm under the AT condition. When the traction was conducted with a 400-g tensile force after intermittent stimulation by 600-g and 400-g tensile forces, the band lengths in the third vertebral joint were 15.43 ± 0.23 cm under the NT condition and 13.62 ± 0.50 cm under the AT condition.

4. Discussion

The meridian sinew theory considers the location and interrelation of sinew channels with heat and cold

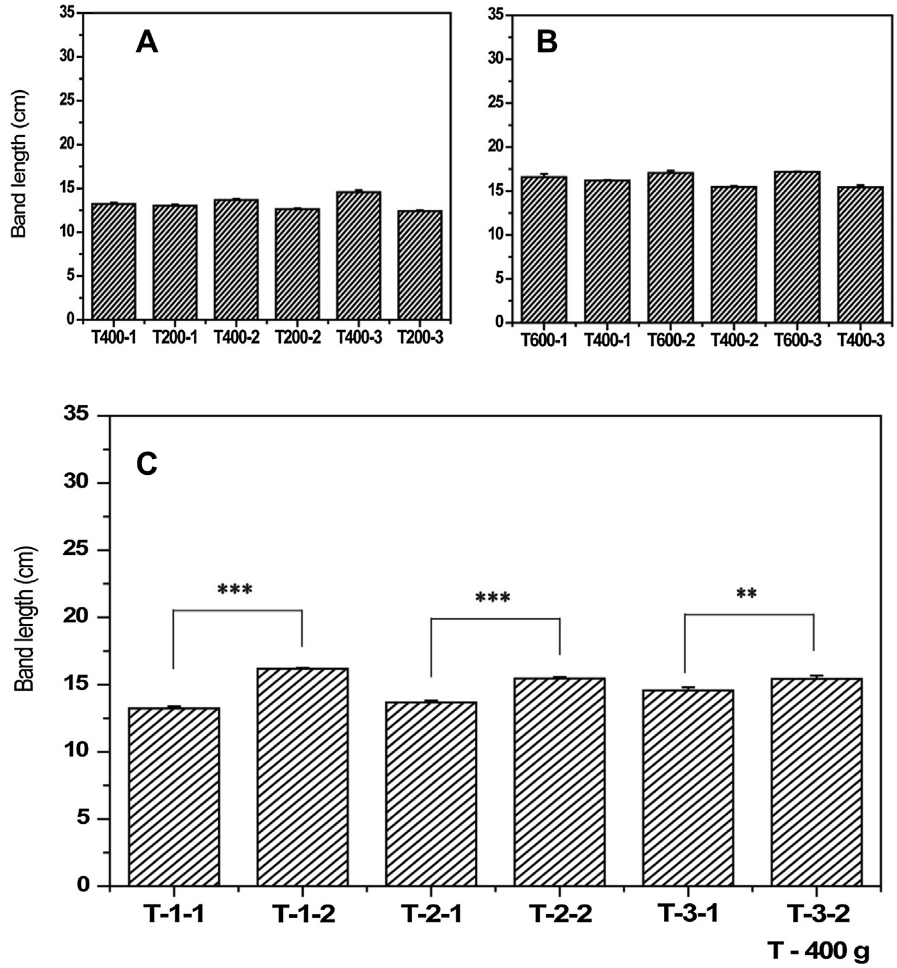

Figure 6 The traction effect of intermittent traction therapy under the NT 2 condition for different tensile forces. The NT 2 model was based on the hypothesis that in articulated spinal model, the muscle contractions of the three spinal joints were equal under normal condition with no pain. The intermittent traction method used a 400—200 g tensile force and a 600—400 g tensile force for 2 minutes in the NT 2 model. (A) T-1-1, T-2-1, T-3-1 are the distances a 400-g tensile force separated the first, second, and third vertebrae after they had been pulled apart by using the 400—200 g intermittent traction method. (B) T-1-2, T-2-2, T-3-2 are the distances a 400-g tensile force separated the first, second, and third vertebrae after they had been pulled apart by using the 600—400 g intermittent traction method. All data are expressed as means $\pm$ standard deviations, triplicate. *** $p < 0.001$. NT = normal type.

symptoms, and the treatments are mentioned in the chapter on Meridian Sinew, Plain Questions in Huangdi's Internal Classic. All of the muscles in the human body are divided into 12 categories similar to the circulation routes of the 12 meridians on the muscles and are given the names of the 12 meridian channels. The 12 meridian sinew channels are the Foot Taiyang, Foot Shaoyang, Foot Yangming, Foot Taiyin, Foot Shaoyin, Foot Jueyin, Hand Taiyang, Hand Shaoyang, Hand Yangming, Hand Taiyin, Hand Jueyin, and Hand Shaoyin Sinew channels. The function of meridian sinews is to control bending and stretching exercises, and the lesions are explained by the motor disturbance such as palsy pain, tetanus, towing pain, spasm, and stiffness in the regional distribution of each meridian sinew; the cold and heat symptoms are explained by muscle contraction and relaxation [1,12,13].

Regarding the relation of meridian sinews and muscles, Lee et al [1] and Han and Yook [2] listed the types of muscles located in the regional distribution of each sinew channel and postulated that one sinew channel could be composed of various muscles, and *vice versa*. Hwang et al [13], explained a sinew meridian as a muscle and tendon; however, Han and Yook [2] said it was composed of multiple muscles, tendons, and ligaments. Regarding the relation of theory to treatment, Kweon et al [4] insisted on the relevance of the Chuna therapy, which is similar to manipulative therapy in western medicine, for the meridian sinew system to the manual therapy of osteopathic medicine as one form of traction therapy. Shin et al [14] focused on the theory and presented a case report on an improved herniated intervertebral lumbar disc treated using chuna therapy for the meridian sinew system; Shin et al [10] also insisted on the relevance of the meridian sinew treatment method to traction therapy.

The vertebral column consists of 33 spinal segments: seven cervical vertebrae, 12 thoracic vertebrae, five

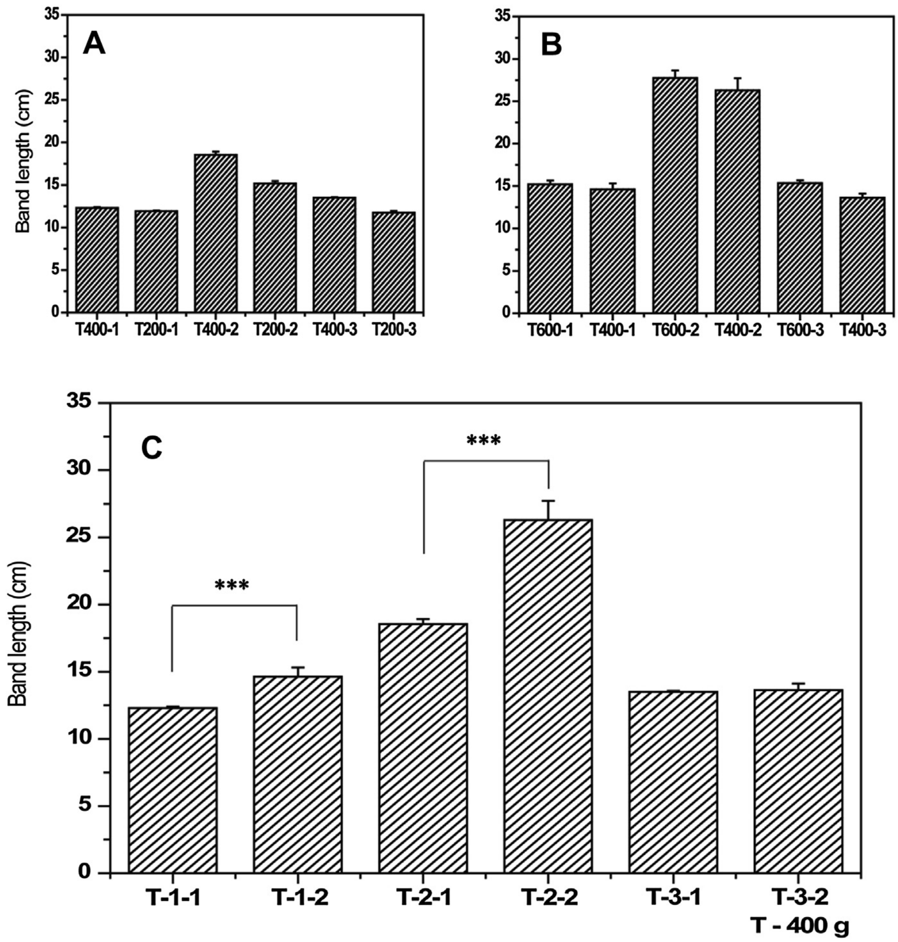

Figure 7 The traction effect for intermittent traction method under the AT 2 condition. The AT 2 model was based on the hypothesis that muscle relaxation of a certain spinal joint region causes spinal disease with pain. In this study, the second joint in the articulated spinal model was relaxed by using one rubber band. (A) T-1-1, T-2-1, T-3-1 are the distances a 400-g tensile force separated the first, second, and third vertebrae after they had been pulled apart using the 400—200 g intermittent traction method. (B) T-1-2, T-2-2, T-3-2 are the distances a 400-g tensile force separated the first, second, and third vertebrae after they had been pulled apart using the 600—400 g intermittent traction method. The intermittent traction methods were completed three times by stretching for 2 minutes each time. All data are expressed as means $\pm$ standard deviations, triplicate. *** $p < 0.001$. AT $=$ abnormal type.

lumbar vertebrae, five sacral vertebrae, and four synsacra. It is supported by many ligaments, such as the ligamentum flavum, supraspinous ligament, interspinous ligament, intertransverse ligament, anterior longitudinal ligament, and posterior longitudinal ligament. The ligaments of the vertebral column restrict and uphold the motion and natural curvature of the spine, and provide stability to the trunk and the overall cervical portion while protecting the spinal cord and providing a passage for spinal nerves [14,15].

Traction therapy, since its design by Hippocrates, has been used as one of the methods to treat scoliosis [5]. The treatment mechanism of traction therapy is to relieve pain and to reduce the pressure caused in the nerve roots by gravity by using mechanical force to stretch the muscles in a particular area in order to increase the negative pressure in the spinal column [6]. Regarding the treatment mechanism, Delacerda postulated that pain was relieved by reducing the tension, impeding extraneous matter, or improving the circulation of the cervical vertebra structure [16]; Wall insisted that the pain was suppressed by the traction stimulus itself at the spinal cord level through stimulation of either the muscle fiber, thereby impeding the neurotransmission of pain, or the afferent fibers of the muscles in the joint area [17]. However, Weinberger emphasized the danger of traction therapy with a hypothesis that neck pain was caused by damaged muscular fibers or connective tissues and that stretching the inflamed structure could be harmful [18].

Experimental results to explain the effect of traction therapy are as follows: Nosse [19] reported that the pain was relieved by traction therapy, which reduced the activities of muscle fibers because the effect of inverted position traction increased the spinal length and reduced the electromyography activities of muscles in the spinal area; Delacerda reported the relevance of increasing traction angles to the activities of muscle fibers in cervical traction therapy [16]. However, traction therapy is still associated with much clinical doubt, in spite of reports to the contrary.

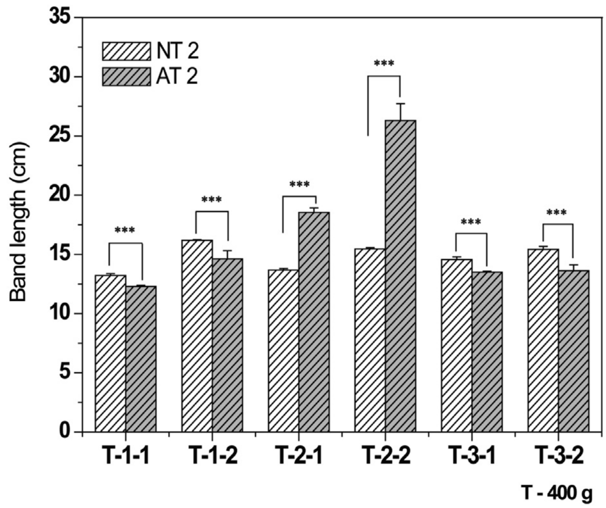

Figure 8 Comparison of the intermittent traction effects under the NT 2 and the AT 2 conditions for stretching by a 400-g tensile force. In the intermittent traction method used to compare the traction effects, stretching was done by using a 400—200 g tensile force and a 600—400 g tensile force for 2 minutes in the NT 2 model and the AT 2 model. T-1-1, T-2-1, T-3-1 are the distances a 400-g tensile force separated the first, second, and third vertebrae after they had been pulled apart using the 400—200 g intermittent traction method. T-1-2, T-2-2, T-3-2 are the distances a 400-g tensile force separated the first, second, and third vertebrae after they had been pulled apart using the 600—400 g intermittent traction method. All data are expressed as means $\pm$ standard deviations, triplicate. ***$p < 0.001$. AT = abnormal type; NT = normal type.

Traction therapy can be classified into various types: continuous traction, sustained traction, and intermittent traction. ITT was developed based on the experimental results of Lawson and Godfrey [8]. In regular traction therapy, different forces and times of traction, that is, a small amount of force for a long time and a large amount of force for a short time traction, have been reported to produce the same effect whereas with ITT, a large amount of force traction has been reported to have a positive treatment effect without giving any pain to the patients. Constantine et al [20] reported the intermittent traction method to be effective for treating patients with cervical radiculopathy. On the contrary, Janneke et al [21] and Thomas et al [22] reported no effect of traction treatment, and Young et al [23] reported indirectly that the intermittent traction method itself had no effect for the patients who had previously received manual therapy or exercise therapy. Jette et al [24] also indirectly reported on the ineffectiveness of intermittent traction method by presenting data from experimental myoelectric activity measurements that showed no significant differences for the upper trapezius muscles of patients who had cervical pain.

According to experimental reports, the effect of ITT is uncertain. Thus, this study aimed to improve traction therapy, to develop the treatment of the meridian sinew, to utilize clinically the experiment results obtained from the vertebrae model, and to observe and analyze the intervertebral traction length due to stimulation by ITT, which is a relatively recent development in treatment methods. To this end, we made a spinal model composed of three joints, similar to the human spine. The spinal model was made with lumber and rubber bands corresponding to vertebrae and muscles, respectively. Based on the hypothesis that muscle contraction causes muscloskeletal diseases like scoliosis or pain in certain regions, NT 1 and NT 2 indicated that the muscle strengths or tensions in the joints were the same or equal whereas AT 1 and AT 2 indicated that the muscle strengths were not equal. The following results were obtained:

Under the NT 1 condition, the traction lengths of vertebral joints were proportional to the tensile force (T400—T200, T600—T400), and the traction lengths were different under different conditions with the same tensile force. That is, the traction length at T400 in the T600—T400 method had 130—150% of traction effect compared to the same tensile force in T400—T200 (Fig. 3). These results indicate that the effects of the intermittent traction method may be superior to the effects of continuous traction [20]. However, under the AT 1 condition, the traction length was observed to be 120—145% longer at T400 when the T400—T200 and the T600—T400 methods were used in the first and the third joint areas, respectively, but the effect of traction on the second vertebral joint was increased by only about 7%, which means that none of the traction effect was observed in the target region, the second joint (Fig. 4).

In addition, the first vertebral joint showed no significant change (Fig. 5) when the first (T400—T200) and the second (T600—T400) types of traction under NT 1 and AT 1 conditions were compared and analyzed at T400, but the traction length of the third vertebral joint was shortened by 3—4 cm. The traction lengths were decreased by nearly 61% and 50% from 21 cm and 28 cm in NT 1 to 13 cm and 14 cm in AT 1 for the second vertebral joint, which was believed to be the cause of pain. This result indicates that ITT has nearly no traction effect in the target region of an articulated joint as in vertebral articulation; this result coincides with the experimental results of Janneke et al [21], and Thomas et al [22], but not with the results of Constantine et al [20].

The results from intermittent traction under NT 2 conditions show that the vertebral joint was strengthened equally (Fig. 6), and the results from intermittent traction under AT 2 conditions show that the second vertebral joint was weakened and that pain was aroused (Fig. 7). None of the traction occurred under the NT 2 condition; the traction force seemed to be possibly too small (Fig. 6). Under the AT 2 condition, however, the traction length of the second vertebral joint was about 18.54 cm with T400 for the T400—T200 condition, and it was 26.31 cm with T400 for the T600—T400 condition; 150% and 210% of traction was observed (Fig. 7). The first and the third vertebral joints, where the band strengths were equal, had no traction effect in the comparison of the NT 2 and the AT 2 conditions. Rather, in contrast to the same situation under the NT 2 condition (Fig. 8), 136% (T400 at T400—T200) and 170% (T400 at T600—T400) traction length increases were observed for the second vertebral joint, which was designed for pain caused by weaken muscles. This result for intermittent traction is somewhat contrary to Lawson and

Godfrey's experimental result, which indicated that the method did not cause pain to patients [8], but this result does explain the result that traction therapy may aggravate the symptoms [25,26].

The above results of this study, which was designed to investigate the effects of ITT in relation to the meridian sinew theory, show that the effects of intermittent traction are still unclear. In addition, the results show that ITT may aggravate the symptoms of the disease, especially pain caused by muscle weakness. Finally, the results of this study are expected to emphasize the differences between the effects of manual traction and those of intermittent traction, as well as the fact that more study of these subjects is necessary.

5. Conclusion

This study aimed to develop an efficient treatment method for meridian sinews by researching muscle treatment methods and ITT. Among muscle treatment methods, the remedial value of ITT is known to be excellent. After observing and analyzing the distances that vertebrae were separated by using the ITT method with various tensile forces, we conclude that the ITT is effective if the muscular strengths of vertebral articulation are equal. Secondly, if the muscular strengths of vertebral articulation are unequal, the effect of ITT cannot reach the region of interest. It can be dangerous if the muscular strength of that region is weakened. These results are based on an experimental spinal column model and were expected to be different from those for manual traction in clinic. Based on these results, further studies are necessary.

Disclosure statement

The author affirms there are no conflicts of interest and the author has no financial interest related to the material of this manuscript.

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